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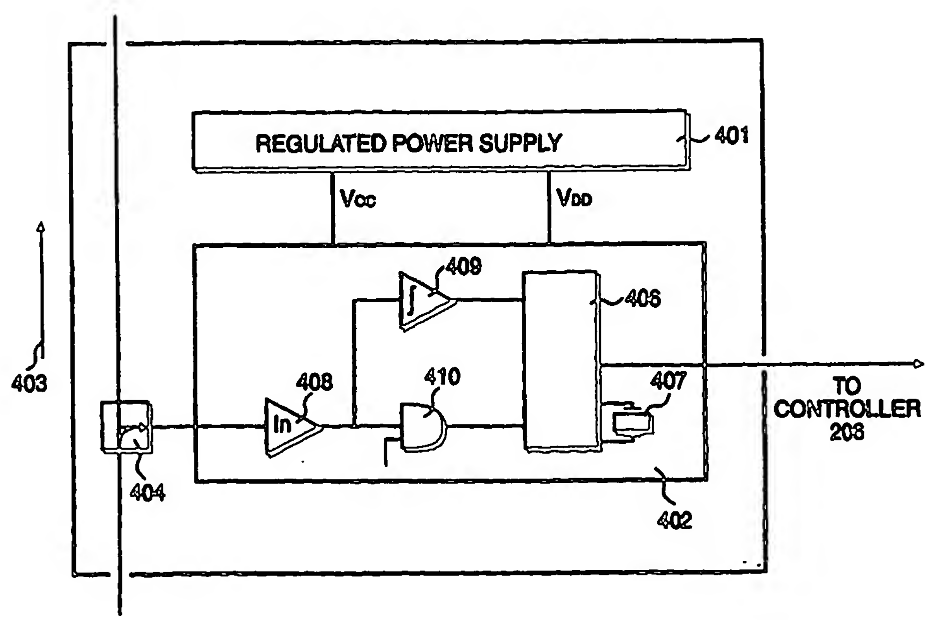

(57) Abstract

Noise is monitored in a noise-sensitive transmission medium, such as coaxial cable forming part of a cable television system. A proportion of a transmitted signal is received from a coaxial cable by a coupling device (404). The received signal is amplified by a logarithmic amplifier (408) so as to reduce the dynamic range of the signal. The amplified signal is compared against a plurality of reference levels by comparators (410) to provide an indication of signal amplitude. The amplitudes are sampled by a processing device (406) so as to provide an indication of signal duration. In addition, background noise is integrated by an integrator (409) so as to provide

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NOISE MONITORING UNIT

The present invention relates to apparatus arranged to be coupled to a noise-sensitive transmission medium and a cable television network having coaxial cable for conveying television signals.

Introduction

Many techniques are known for the transmission of information, either in analog or in digital form, over electrical conductors. It is known that coaxial cable provides a greater bandwidth than other techniques, such as twisted wire pairs and, traditionally, television signals and multiplexed telephone signals have been transmitted using this medium. The medium facilitates signal distribution and amplification, with termination and interconnection devices being of relatively modest construction. However, a known problem with electrical conducting media is their susceptibility to induced noise, often created by electrical equipment in the vicinity. Coaxial transmission systems are particularly susceptible to this noise at junction locations and terminations where, to a greater or lesser extent, the shielding of the coaxial cable will have been removed in order to effect electrical connection to an inner core of a coaxial cable. It is also known that a relatively poor connection at one position within a coaxial network will allow induced noise signals to propagate throughout the network. Thus, a single bad connection may impair the overall quality and integrity of the network at positions displaced significantly away from the point at which the noise is being introduced.

Summary of The Invention

According to a first aspect of the present invention, there is provided apparatus for monitoring noise in a noise-sensitive transmission medium, comprising coupling means for coupling said apparatus to a transmission medium at a selected location; means for detecting noise amplitudes; and processing means for analysing said noise amplitudes and for generating an encoded representation of said amplitudes for transmission to a monitoring station.

In a preferred embodiment, the processing means is configured to measure the duration of detected noises and the apparatus may include a micro-controller for measuring noise durations.

In a preferred embodiment, said means for identifying noise amplitudes includes a plurality of level comparators and an input signal may be supplied to said comparators via a logarithmic amplifier/detector. Preferably, the outputs from said comparators are sampled so as to measure the duration of a noise signal.

In a preferred embodiment, the apparatus includes an integrator for averaging ingress noise and the output from said integrator may be supplied to a comparator. Preferably, said integrator is disabled if input noise exceeds a predetermined level.

According to a second aspect of the present invention, there is provided a method of monitoring noise in a noise-sensitive transmission medium, comprising steps of receiving a proportion of a signal transmitted through said medium; amplifying said received signal logarithmically so as to reduce the dynamic range of said signal; comparing said amplified signal against a plurality of reference levels to provide an indication of signal amplitude; and sampling said signal amplitudes so as to provide an indication of signal duration.

In a preferred embodiment, said method includes the step of integrating said amplified signal to produce an average value for background noise. Preferably, said integrated value is compared against a reference value and said integration may be disabled if an input signal exceeds a predetermined level.

According to a third aspect of the present invention, there is provided a cable television network having coaxial cable for conveying television signals and data in a forward direction and for conveying data in a reverse direction, wherein transmission in said reverse direction is sensitive to induced noise, comprising a plurality of noise monitoring units coupled to respective parts of said coaxial cable, each having means for identifying noise amplitudes; and processing means for analysing said noise amplitudes and for supplying an encoded representation of said amplitudes to a controller.

Brief Description of The Drawings

Figure 1 shows a hybrid fibre coaxial cable television network, having a plurality of opto-electronic nodes;

Figure 2 details an opto-electonic node of the type shown in Figure 1, having noise monitoring units.

Figure 3A shows the available bandwidth for the transmission of information within the network shown in Figure 1;

Figure 3B identifies different types of noise in terms of its amplitude and duration;

Figure 4 details a noise monitoring unit of the type shown in Figure 2, including a coupling device and a noise processing circuit; and

Figure 5 details the noise processing circuit identified in Figure 4, including a micro-controller;

Figure 6 shows operations performed by the micro-controller identified in Figure 5, including an impulse processing step; and

Figure 7 details the impulse processing step identified in Figure 6.

Detailed Description of The Preferred Embodiments

The invention will now be described by way of example only with reference to the previously identified drawings.

A number of papers given at the European Conference on Optical Communication in 1996 identified the use of hybrid optical fibre and coaxial (HFC) networks as a preferred solution to providing new telecommunication environments. It was acknowledged that a fully optical fibre to the home (FTTH) system provides a technically superior solution but, using present technology, this is off-set by the significant additional cost.

The majority of HFC networks are of the tree and branch type in which all signals originating from a head end are simultaneously transmitted to all receivers. A head end 101 of this type is shown in Figure 1, having a plurality of optical fibre transmission paths 102, configured to supply signals to and receive signals from

respective opto-electronic nodes 103, where conversion takes place, between the optical signals and radio frequency electrical signals, for transmission to customers via a coaxial network.

Each optical-electronic node is connected to four physically separate coaxial branches, such as branches 104, 105, 106 and 107 shown in Figure 1. Each coaxial branch (104 to 107) typically supplies 175 customers and the distribution to these customers may occur over a single branch, as illustrated by branch 107 or, alternatively, sub-branches, such as sub-branch 108 may be connected to a main branch. As illustrated in Figure 1, when sub-branches are developed, they would typically include an additional amplifier 109 so as to amplify the signal over the additional transmission path.

Customers, such as customers 110 and 111 are connected to a coaxial branch (107) via a coaxial tap 112 and a drop cable 113. In the cable television environment and given the large bandwidth requirement for television signals, the majority of the available bandwidth throughout the network is used for the transmission of television signals. Recently, it has been proposed to make enhanced use of this available bandwidth, allowing more television channels to be transmitted to customers, by invoking a process of signal digitisation and compression, possibly in accordance with proposals made by the Moving Picture Expert Group (MPEG). However, through a process of frequency division multiplexing, it is also possible to convey data throughout the network which may be transmitted in a reverse direction, ie from a customer (110) back to the head end 101 in addition to being transmitted in the conventional forward direction.

Once full duplex data transmission paths have been established in this way, it is possible to use these data paths for the transmission of any appropriate type of data, which may include encoded speech, text or signalling etc. Thus, it is possible for a cable network operator to provide full duplex telephone and data communications, placed over the existing cable television service. Furthermore, from an operators point of view, the provision of such services can be very profitable, given that users expect to pay significantly more, on a time basis, than that paid for the provision of television services. Thus, most cable operators are

very pleased to provide services of this type, in addition to the conventional cable television traffic. However, it is these data services, transmitted in the reverse direction at lower carrier frequencies, which are particularly susceptible to induced noise, therefore operators are constantly looking for ways in which noise of this type may be quickly identified, so that appropriate repairs may be made to the network.

Opto-electronic node 103 is detailed in Figure 2 and includes opto-electronic transducers 201 for performing conversions between optical signals transmitted on optical trunk 102 and electrical signals transmitted on coaxial cables 104, 105, 106 and 107.

The opto-electronic nodes also include a plurality of noise monitoring units 202, 203, 204 and 205, each coupled to a respective coaxial trunk 104 to 107. The noise monitoring units are configured to identify noise amplitudes and include processing circuits for analysing these noise amplitudes and for supplying an encoded representation of these identified amplitudes to a processing device. Processing device takes the form of a master controller 206. In addition, the master controller 206 also includes a transmission device 208 so as to allow data captured by the opto-electronic node, as received from its noise monitoring units, to be relayed to a central station, possibly positioned at the cable head end 101.

The availability of transmission bandwidth through the coaxial cable network is illustrated in Figure 3A. The coaxial cables of the trunk network (117) and the drop cables (113) allow modulated signals to be transmitted up to a maximum frequency of 1000 MHz (1 GHz) and band 201 represents the spectrum of 88 MHz to 1 GHz allocated for downstream services, that is from the cable head-end to the customers. By far the bulk of the bandwidth is made available for transmission in this direction because this level of bandwidth is required for the transmission of television signals.

The portion of the spectrum referenced 302 represents a region from 5 MHz to 60 MHz for the transmission of upstream services, in the form of signalling information and customer-generated information. Induced noise, to which this portion of the spectrum is particularly sensitive, may be categorised as being made

up of two distinctive components, identified as impulse noise and ingress noise. Impulse noise has a relatively short duration and occupies a relatively large frequency band. It is usually generated by electrical components being switched off, resulting in the generation of inductive spikes. Ingress noise has a relatively long duration and may occupy the whole or a major part of the available spectrum (as would be the case with thermal noise) or may occupy a small frequency band or even a single frequency, as would be the case if the noise was due to a weakness in RF shielding.

The nature of the noise is determined by the nature of the noise source and a fault in the network, possibly in the form of a loose or corroded tap 112, would provide an antennae for stray electromagnetic waves resulting in an induced electromotive-force being introduced to the cable network. Thus, identifying the point at which noise enters the system allows an operator to identify a potential fault in the network, thus facilitating prompt corrective measures. By identifying the type of noise entering the network, it may be possible to identify an extraneous noise source and possibly advise customers how to eradicate that source or at least mitigate its effects. Problems of this type may also occur if customers add additional wiring themselves, possibly to provide terminals in additional rooms, without being aware or the consequential effects on the network as a whole. Furthermore, network operators are under considerable pressure to ensure that high valued data communications services remain available when required by customers, given that problems associated with communicating over a common coaxial cable do not generally exist within switched telephone network environments.

The types of noise which may be identified by the noise monitoring units, such as unit 114, are illustrated in Figure 3B. In Figure 3B, noise levels, measured in milli-volts considered on a logarithmic (dB) scale are plotted against noise duration, quantised into periods of one microsecond, ten microseconds, one hundred microseconds and one thousand microseconds. Given the nature of components within the noise monitoring unit, values below –30dBmV, shown as region 301, may be due to noise generated within the unit itself and are therefore disregarded. Noise detected over a level of –30dBmV is considered to be noise

received by the coaxial cable being monitored and when noise above –30dBmV is detected, information to this effect is returned to the opto-electronic node. This would usually be in the form of ingress noise, tending to be relatively continuous.

As shown in Figure 3, further thresholds at -10dBmV, +10dBmV, +30dBmV and +50dBmV are also considered, although ingress noise above a level of -10dBmV would suggest that a major configuration error has occurred which, under normal circumstances would tend not be the case. Thus, the noise monitoring unit is primarily designed to identify changes to the operating environment on the assumption that no major construction or design faults are present and that, given ideal conditions, noise of the type detected by the units should not occur. Thus, if noise above the -10dBmV level is detected, such noise will tend to be of a transient nature and further information may be relayed back to node 103 identifying the duration of the noise in addition to its amplitude. Thus, the unit is configured to identify noise spikes which exceed minus 10dBm V, plus 10dBmV, 30dBmV or 50dBmV.

In addition, it is possible to convey information as to the duration of the spike, to a quantisation of less than one microsecond, more than one microsecond, more than ten microseconds, more than 100, microseconds or more than one millisecond. Thus, each detected incident of noise is categorised as belonging to one of seventeen types 351 to 367. Noise type 351 represents ingress noise having an amplitude of between minus 30 and minus 10dBmV and of unspecified duration. Noise types 352 to 367 are categorised in terms of both their amplitude and their duration, as detailed in Figure 3B. This categorisation of noise assists in the identification of the source of the noise, thereby facilitating the taking of appropriate action.

Noise monitoring unit 114 is detailed in Figure 4 and includes a regulated power supply 401 with a noise processing circuit 402. Data is transmitted from a customer (110) back to the head end 101. This transmission channel will include noise in addition to modulated data and a conventional coupler 404 is configured to supply a proportion of the radio frequency information to the noise processing circuit 402. The noise processing circuit generates data representing the state of

noise detected on the transmission cable as detailed in Figure 3B, which is supplied to the master controller 206.

The noise processing circuit 402 includes a micro controller 406 connected to a quartz oscillator 407. Quartz oscillator 407 provides clocking signals throughout the processor 406 and also allows the processor 406 to maintain a real time clock such that data supplied to controller 206 may also include timing information, identifying the time at which transient noise is actually detected. Again, this information may be extremely useful when investigating a noise source.

In order to facilitate the handling of a large input range, signals supplied to processor 402 are received by a logarithmic amplifier 408, configured to provide an output voltage which varies logarithmically with the input voltage. Thus, logarithmic amplifier 408 is sensitive to low voltage input levels allowing these voltage levels to be detected. However, as the input voltage increases significantly, the output voltage varies to a much lesser extent, thereby allowing the processing circuit 402 to be responsive to a wide dynamic range of input signals.

The output from logarithmic amplifier 408 is supplied to an integrating circuit 409, arranged to continuously integrate output signals from the logarithmic amplifier 408 so as to provide an instantaneous value to processor 406 representing a running average of input noise. Thus, the integration circuit 409 provides a mechanism for monitoring ingress noise, which may be considered as having an average level, monitored within the region of -30dBmV to -10dBmV.

In addition to being supplied to the integrating circuit, the output from logarithmic amplifier 408 is also supplied to a group of comparators, identified generally by comparator 410. These comparators are configured to identify noise spikes exceeding levels of -10dBmV, +10dBmV, + 30dBmV and + 50dBmV. The comparators are also configured with positive feedback such that, once activated, they remain set and are then reset by micro controller 406.

By performing reset operations at an appropriate frequency, the micro controller 406 is capable of detecting the duration of a spike which, as identified in Figure 3, is quantised in time in addition to being quantised in amplitude. Comparator 410 is also configured to disable the integrating circuit 409 when spikes

are detected, so that said spikes do not add to the measurement of ingress noise, which would result in an inaccurate representation of the average. Thus, having detected the presence of noise, the noise monitoring unit is arranged to categorise the noise in terms of its ampitude, and, where appropriate its duration, such that, in response to a polling signal received from the master controller 206, noise related information is coded by the micro-controller 406 for transmission in the form of a thirty-byte message.

The power supply 401 includes a regulator for receiving an unregulated input via an electrolytic capacitor, to effect waveform smoothing, and a ceramic capacitor for the removal of RF components. The power supply 401 supplies two isolated supplies for analog components (Vcc) and for digital components (Vdd). De-coupling capacitors are also associated with switching components, as is known in the art, primarily to prevent high frequency signals generated by digital circuitry from affecting the analog circuitry and in particular from affecting the logarithmic amplifier 408.

Noise processing circuit 402 is shown in greater detail, at circuit component level, in Figure 5. Logarithmic amplifier 408 is implemented as an AD606, 501, supplied by Analog Devices of Norwood, Massachusetts, USA. This device is a complete monolithic logarithmic amplifier using a nine stage successive-detection technique to provide both logarithmic and limited outputs. The logarithmic output is from a 3-pole post demodulation low pass filter and provides a loadable outward voltage of 0.1 volts dc to 4 volts dc. The logarithmic scaling is such that the output is +0.5 volts for a sinusoidal input of -75 dBm and +3.5 volts at an input of +5 dBm; over this range the logarithmic linearity is typically within plus or minus 0.4 dB and all of the scaling parameters are proportional to the supply voltage.

Output from coupler 404 is supplied to input port 502 which is in turn connected to pins 16 and 1 of device 501 via a capacitor 503 of 100 pico-farads, and a resistor 504 of 75 ohms in series with a capacitor 505 also of 100 pico-farads, respectively. Resistor 504 is connected to ground and defines the input impedance. The combination ensures that any noise common to analog ground and the RF input is cancelled out.

Pin 12 is connected to pin 11 via a capacitor 506 of 100 pico-farads in series with a resistor 507 of 2 kilo-ohms to provide a time constant for an internal voltage reference generating circuit. Vcc is de-coupled by a capacitor 508 of 100 nano-farads. As pins 8 and 9 are not used, they are connected to Vcc. This reference voltage is divided by resistors 509 and 510, of 9.1 kilo-ohms and 1.2 kilo-ohms to provide a reference voltage on the negative inputs of four comparators 511, 512, 513 and 514.

The logarithmic output from amplifier 501 is supplied from pin 6 to an integrating circuit via resistor 515 of 12 kilo-ohms. This output is also supplied to the positive input of each comparator 511 to 514, via respective resistors 516 of 11 kilo-ohms, 517 of 27 kilo-ohms, 518 of 47 kilo-ohms and 519 of 56 kilo-ohms. Each comparator 511 to 514 operates as a Schmitt trigger due to a positive feedback resistors 521, 522, 523, 524 respectively, each of 10 kilo-ohms. Each device therefore has two stable states. After the application of a reset signal, the comparators produce a low output. After being triggered, by an appropriately high voltage applied to their positive input, the triggers enter a state producing a high output and remain in this state until reset again. The ratio between the feedback resistor, such as resistor 521, and its associated input resistor, such as resistor 516, defines the voltage at which this triggering occurs. Thus, signals amplified by the logarithmic amplifier 501 and supplied to the comparator chain by output Pin 6, may result in one or more of said comparators being tripped, thereby setting its output voltage level to the high state.

Micro-controller 406 is a PIC 16C61 8 bit device manufactured by Arizona Microchip. It provides a serial interface implemented by an interrupt line 525, a clock line 526 and a data line 527. An interrupt is received from the master-controller 206, in combination with clocking signals. In response to this interrupt, effecting a polling of the micro-controller 406, information is transmitted by the micro-controller over data line 527.

Outputs from comparators 511 to 514 are supplied to respective inputs, RB1, RB2, RB3 and RB4 of the micro-controller 406. The micro-controller is configured to poll each of its pins, represented as being at an addressable location,

whereafter information is recorded if a change of stage is detected. Operation of the micro controller 406 is initiated on power up. A reset line 528, resetting the device when low, remains low until capacitor 529 of 100 nano-farads has been charged by resistor 530 of 1.2 kilo-ohms.

Devices 531, 532 and 533 are switches fabricated on a common chip, which become conductive when a high level is supplied to their control input. The processor 406 is therefore configured to supply a control voltage, from output RA3, to device 531, resulting in the negative inputs of all of comparators 511 to 514 being pulled high, thereby resetting all of said comparators. Thus, this part of the circuit completes the relationship between the comparator 410 and processor 406.

The integrator 409 consist of an operational amplifier 534 with a capacitor 535 of 10 nano-farads and a resistor 536 of 36 kilo-ohms in its negative feedback path. Comparator 511 is configured to detect voltages in excess of −10dBmV and on detecting these conditions, its output is placed into a high state. In addition to being supplied to input RB1 of micro controller 406, this high level is also relayed to switch 532, connected between a supply voltage and ground. The supply voltage is supplied to device 532 by a resistor 537 of 8.2 kilo-ohms, which in turn supplies a control voltage to device 533. When device 533 becomes conducting, the voltage supplied to the control input of device 533 is pulled down resulting in device 533 becoming non-conducting. In this way, the output from pin 6 of the logarithmic amplifier 501 is prevented from being supplied to the negative inputs of operational amplifier 534, thereby ensuring that any voltage spikes in excess of −10dB mV are not supplied to the integrating circuit.

A reference voltage is supplied to the positive input of operational amplifier 534 via a voltage divider, formed by resistors 537 of 8.2 kilo-ohms and 538 of 2.7 kilo-ohms, in combination with filtering capacitor 539 of 100 nano-farads. The ratio of the capacitance of capacitor 535 over the resistance of resistor 536 defines the time constant for the integrator and the integrated output is supplied to a comparator 540.

A reference voltage is supplied to an Analog Device CMP402 comparator 540 by a voltage divider defined by resistors 541 of 43 kilo-ohms and 542 of 100

kilo-ohms, with the capacitor 543 of 100 nano-farads providing filtering of the power supply.

Devices 531, 532 and 534 are 4066B quad bi-lateral switches which, when conducting, present a resistance of a few ohms but when placed in their non-conducting state present a resistance of several Gigaohms. The output from comparator 540 is supplied to input port RA2 of the micro controller. This information relates to ingress noise supplied to the micro controller which is packaged and transmitted along with the summary information representing transient noise.

Operations performed by micro controller 406 are illustrated in Figure 6. The micro controller is initialised on start up at step 601. Comparators 511, 512, 513, 514 and 540 are reset at steps 602. At step 603 a question is asked whether a new impulse is detected. If this question is answered in the affirmative the micro controller pauses at step 604 and then returns control back to step 603. If the question asked at step 603 is answered in the negative control is passed to step 605. At step 605 the question is asked whether if there is still an impulse detected. If this question is answered in the negative control is passed to step 606 with micro controller waits before passing control back to step 603. If the question asked at step 605 is answered in the affirmative control is passed to step 607. At step 607 the impulse is measured and the resulting measurement data is processed and control is subsequently passed to step 608. At step 608 the process measurements data is stored in readiness for transmission and control is passed back to step 603.

Measurement and data processing step 607 is shown in detail in Figure 7. At step 701 the impulse is measured for one microsecond and this measurement value is stored for later processing. At step 702 the impulse is measured for 10 microseconds, and this measurement is stored for later processing. At step 703 a question is asked whether an impulse is present. If this question is answered in the affirmative control is passed to step 704 wherein the impulse is measured for 100 microseconds and this result is stored for later processing. Control is then passed to step 705 where a question is asked whether an impulse is present. If this question is answered in the affirmative control is passed to step 706 wherein the impulse is

measured for 1000 microseconds and this result is stored for later processing. Control is then passed to step 707 where a question is asked whether the present impulse is due to data signals. If this question is answered in the negative control is passed to step 708 where the average value for 1000 microseconds is calculated. Control is then passed to step 709 at which the average value for 100 microseconds is calculated. Control is then passed to step 710. Step 710 also follows from step 703 if the question asked therein was answered in the negative. At step 710 the average value for 10 microseconds is calculated.

Claims

1. Apparatus for monitoring noise in a noise-sensitive transmission medium, comprising

coupling means for coupling said apparatus to a transmission medium at a selected location;

means for detecting noise amplitudes; and

processing means for analysing said noise amplitudes and for generating an encoded representation of said amplitudes for transmission to a monitoring station.

2. Apparatus according to claim 1, wherein said processing means is configured to measure the duration of detected noise.

3. Apparatus according to claim 2, wherein said processing means includes a micro-controller for measuring noise durations.

4. Apparatus according to any of claims 1 to 3, wherein said means for identifying noise amplitudes includes a plurality of level comparators.

5. Apparatus according to claim 4, wherein an input signal is supplied to said comparators via a logarithmic amplifier/detector.

6. Apparatus according to claim 4 or claim 5, wherein the outputs from said comparators are sampled so as to measure the duration of a noise signal.

7. Apparatus according to any of claims 4 to 6, wherein said comparators are configured as bistable devices with positive feedback.

8. Apparatus according to any of claims 1 to 7, wherein said means for identifying noise amplitudes includes an integrator for averaging ingress noise.

9. Apparatus according to claim 8, wherein the output from said integrator is supplied to a comparator.

10. Apparatus according to claim 8 or claim 9, wherein said integrator is disabled if input noise exceeds a predetermined level.

11. A method of monitoring noise in a noise-sensitive transmission medium, comprising steps of

receiving a proportion of a signal transmitted through said medium;

amplifying said received signal logarithmically so as to reduce the dynamic range of said signal;

comparing said amplified signal against a plurality of reference levels to provide an indication of signal amplitude; and

sampling said signal amplitudes so as to provide an indication of signal duration.

12. A method according to claim 11, including the steps of integrating said amplified signal to produce an average value for background noise.

13. A method according to claim 12, wherein said integrated value is compared against a reference value.

14. A method according to claim 12, wherein said integration is disabled if said input signal exceeds a predetermined level.

15. A cable television network having coaxial cable for conveying television signals and data in a forward direction and for conveying data in a reverse direction, wherein transmission in said reverse direction is sensitive to induced noise, comprising a plurality of noise monitoring units coupled to respective parts of said coaxial cable, each of said noise monitoring units having

means for identifying noise amplitudes, and

processing means for analysing said noise amplitudes and for supplying an encoded representation of said amplitudes to a controller.

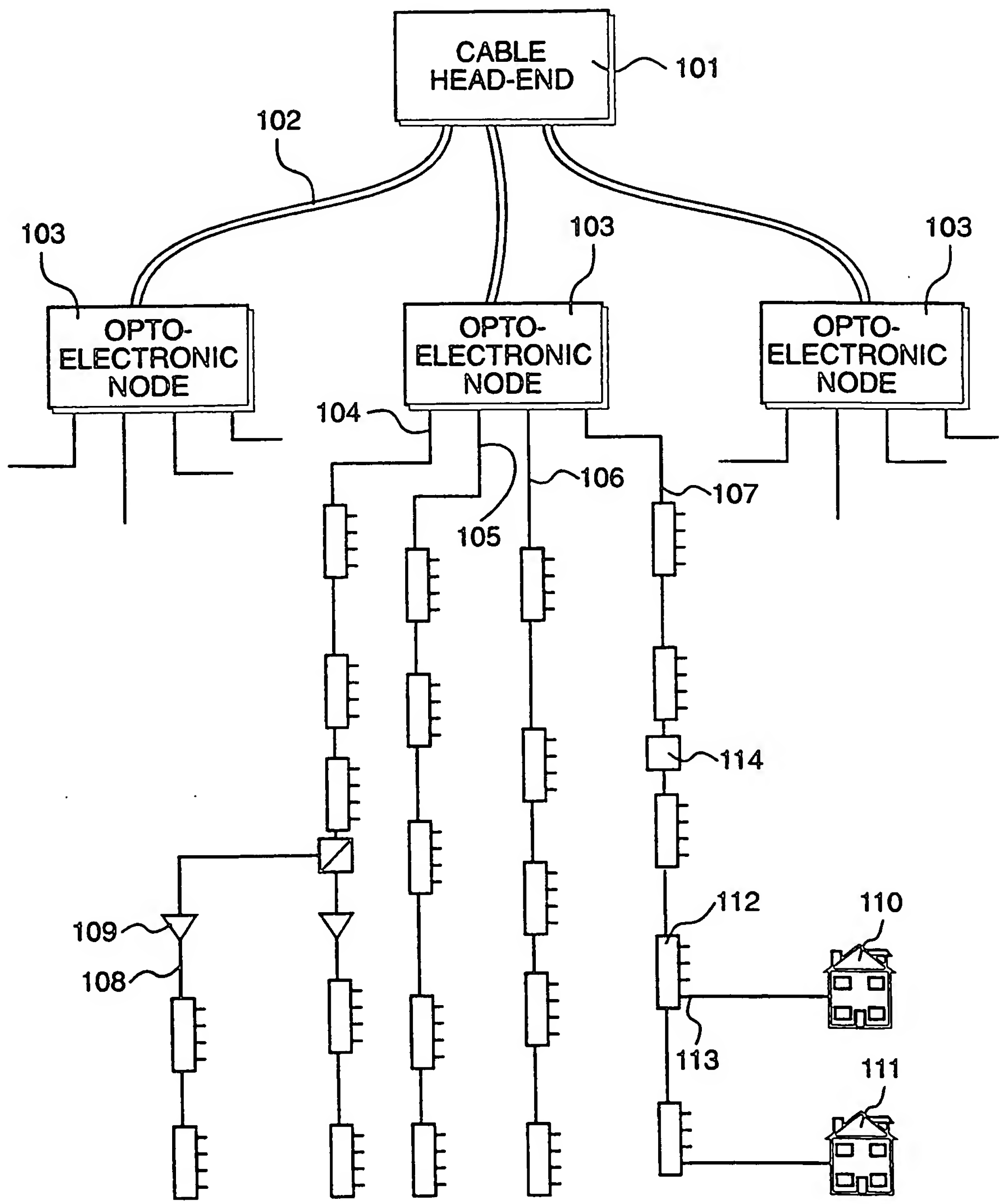
16. A network according to claim 15, wherein a plurality of coaxial cables communicate with an optical trunk cable via an opto-electronic node.

17. A network according to claim 16, wherein said noise monitoring units are coupled to said coaxial cable at positions close to said opto-electronic nodes.

18. A network according to claim 16 or claim 17, wherein said controllers are positioned at the opto-electronic nodes.

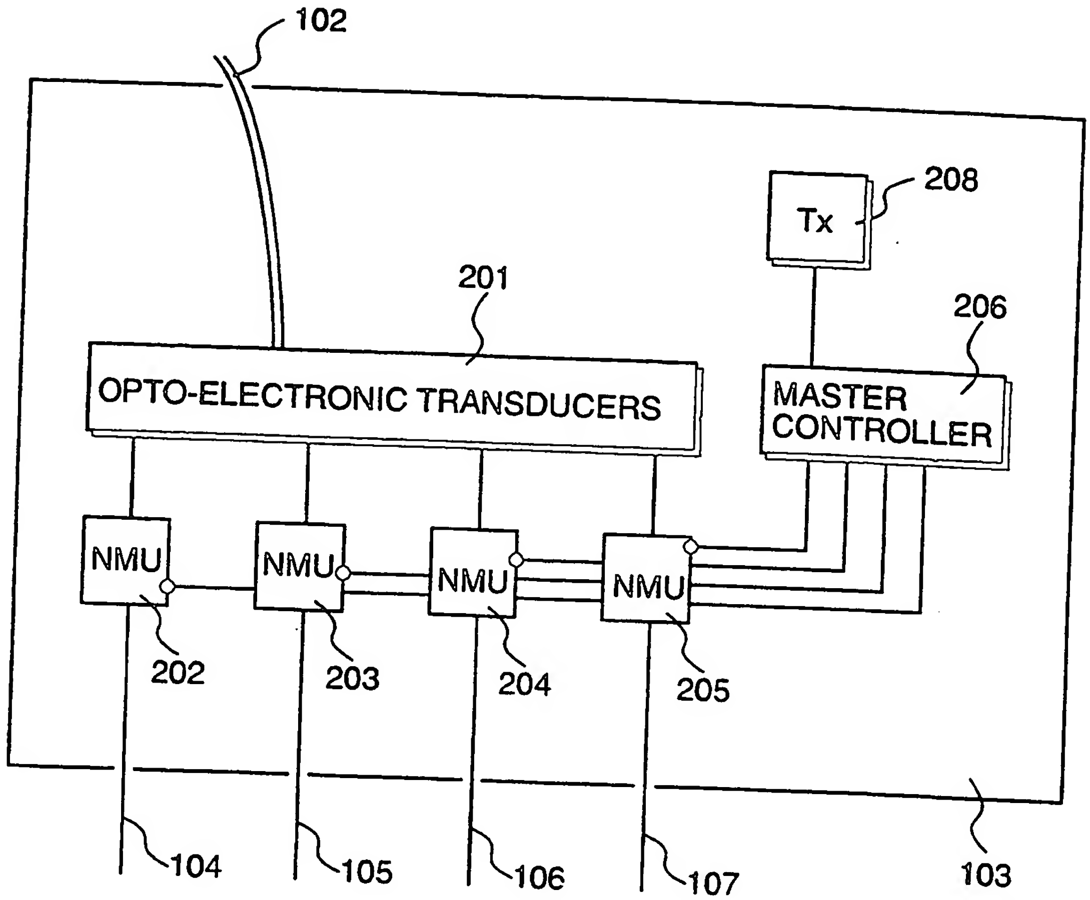
19. A network according to claim 18, wherein a controller supplies information back to a cable head end.

20. A network according to claim 19, wherein information is supplied back to said head end via said optical trunks.



CABLE HEAD-END
101
102
103
103
103
OPTO-ELECTRONIC NODE
OPTO-ELECTRONIC NODE
OPTO-ELECTRONIC NODE
104
105
106
107
114
112
110
109
108
113
111

Figure 1


102
208
Tx
201
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OPTO-ELECTRONIC TRANSDUCERS
MASTER CONTROLLER
NMU
NMU
NMU
NMU
202
203
204
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105
106
107
103

Figure 2

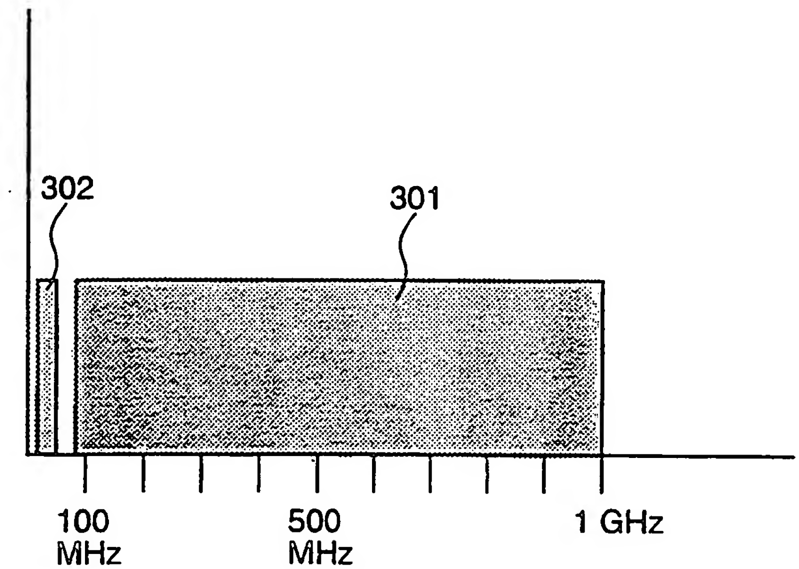

Figure 3A

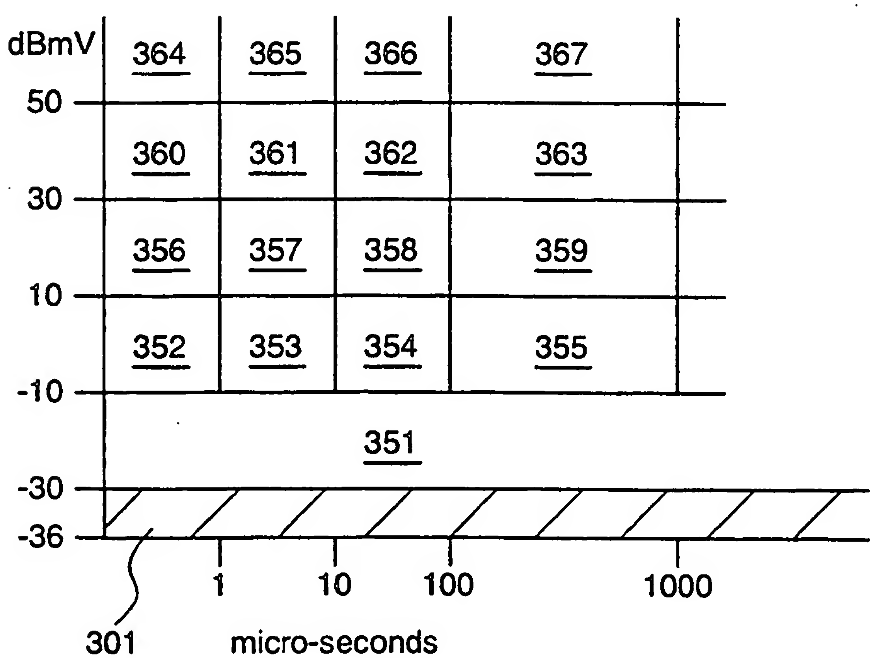

Figure 3B

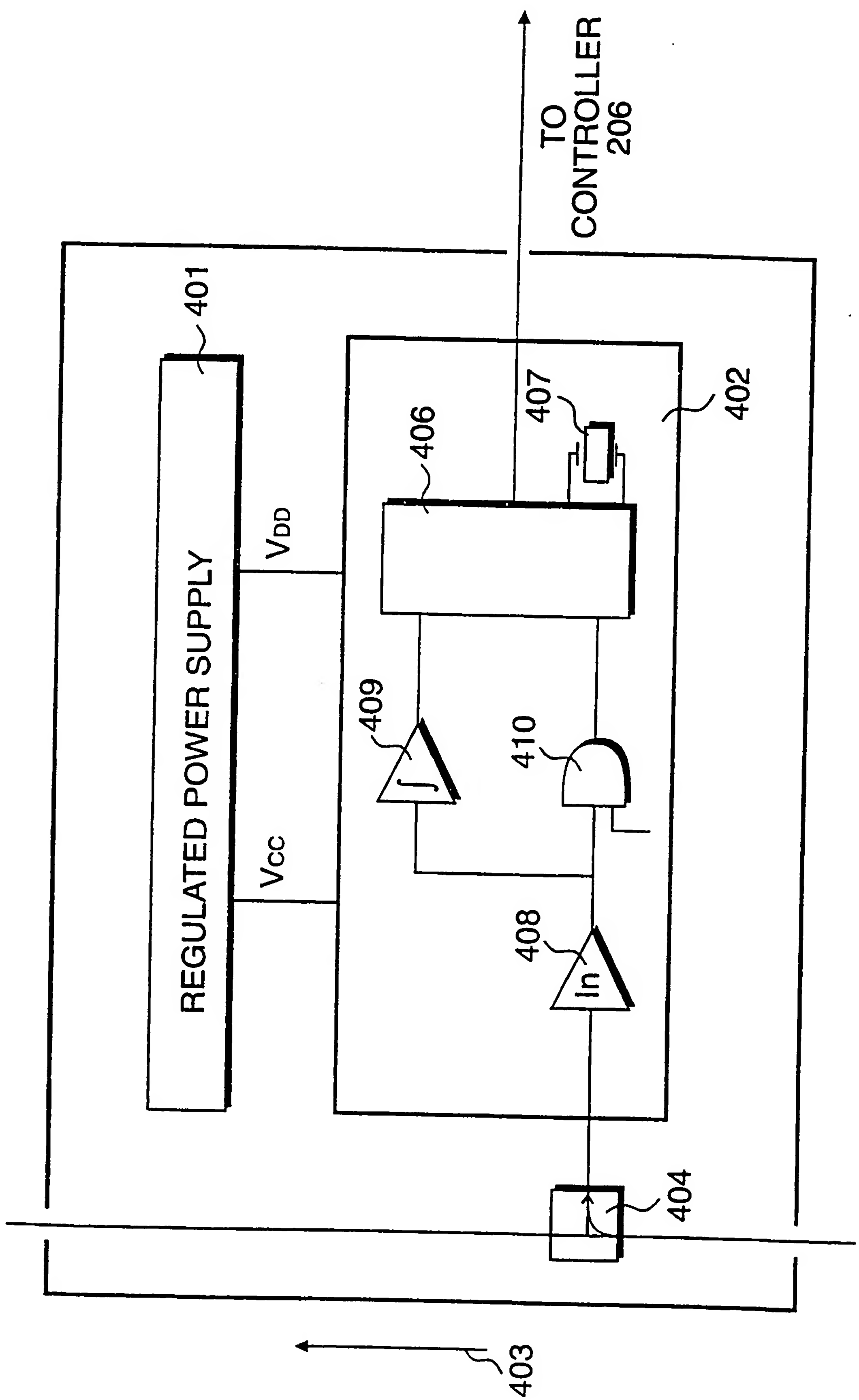
TO CONTROLLER 206
401
REGULATED POWER SUPPLY
VDD
VCC
406
407
402
409
410
408
In
404
403

Figure 4

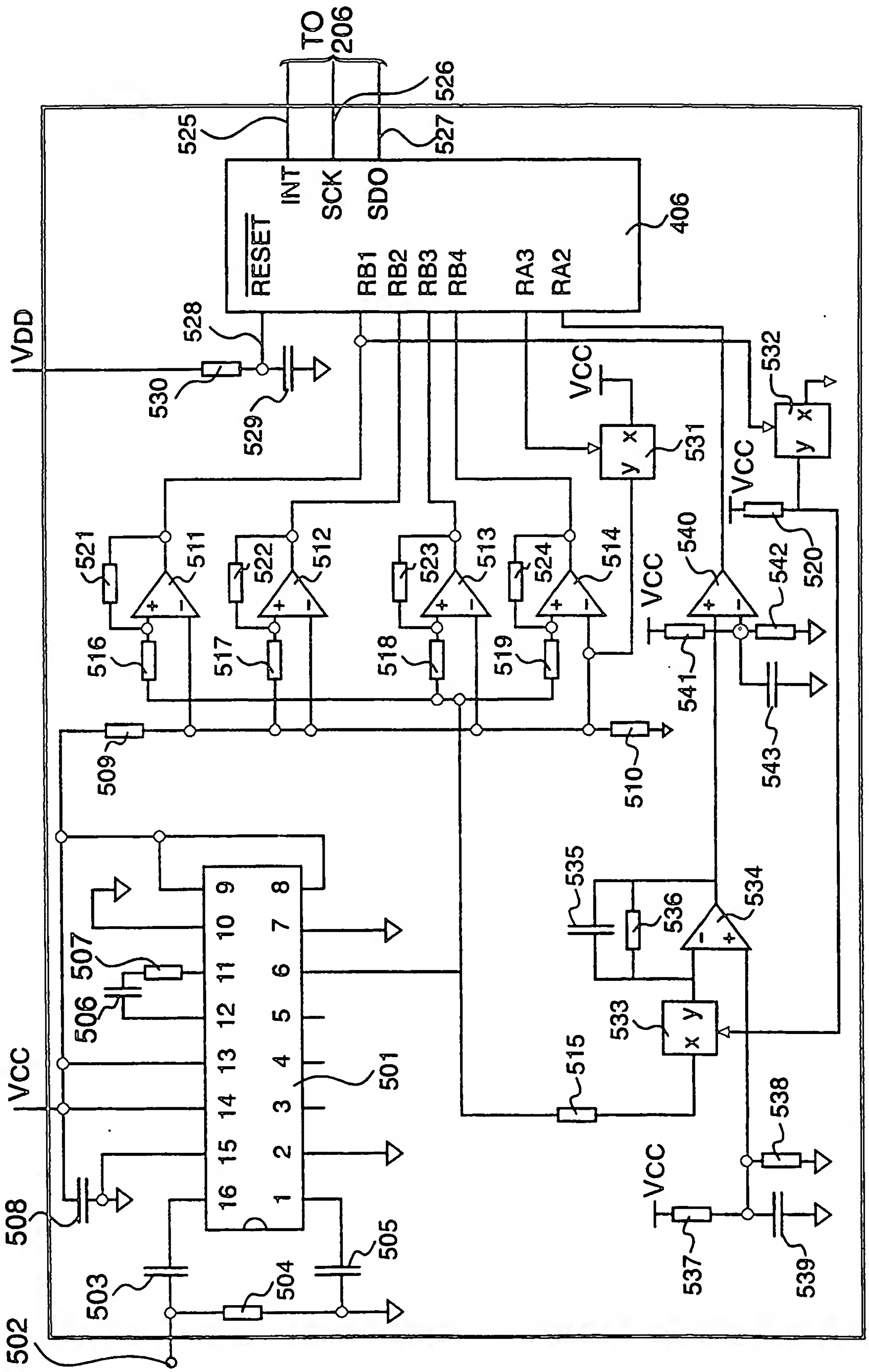
TO 206
525
526
527
INT
SCK
SDO
RESET
RB1
RB2
RB3
RB4
RA3
RA2
406
VDD
528
529
530
VCC
531
532
511
512
513
514
516
517
518
519
521
522
523
524
520
540
541
542
543
509
510
501
502
503
504
505
506
507
508
533
534
535
536
537
538
539
515
y
x

Figure 5

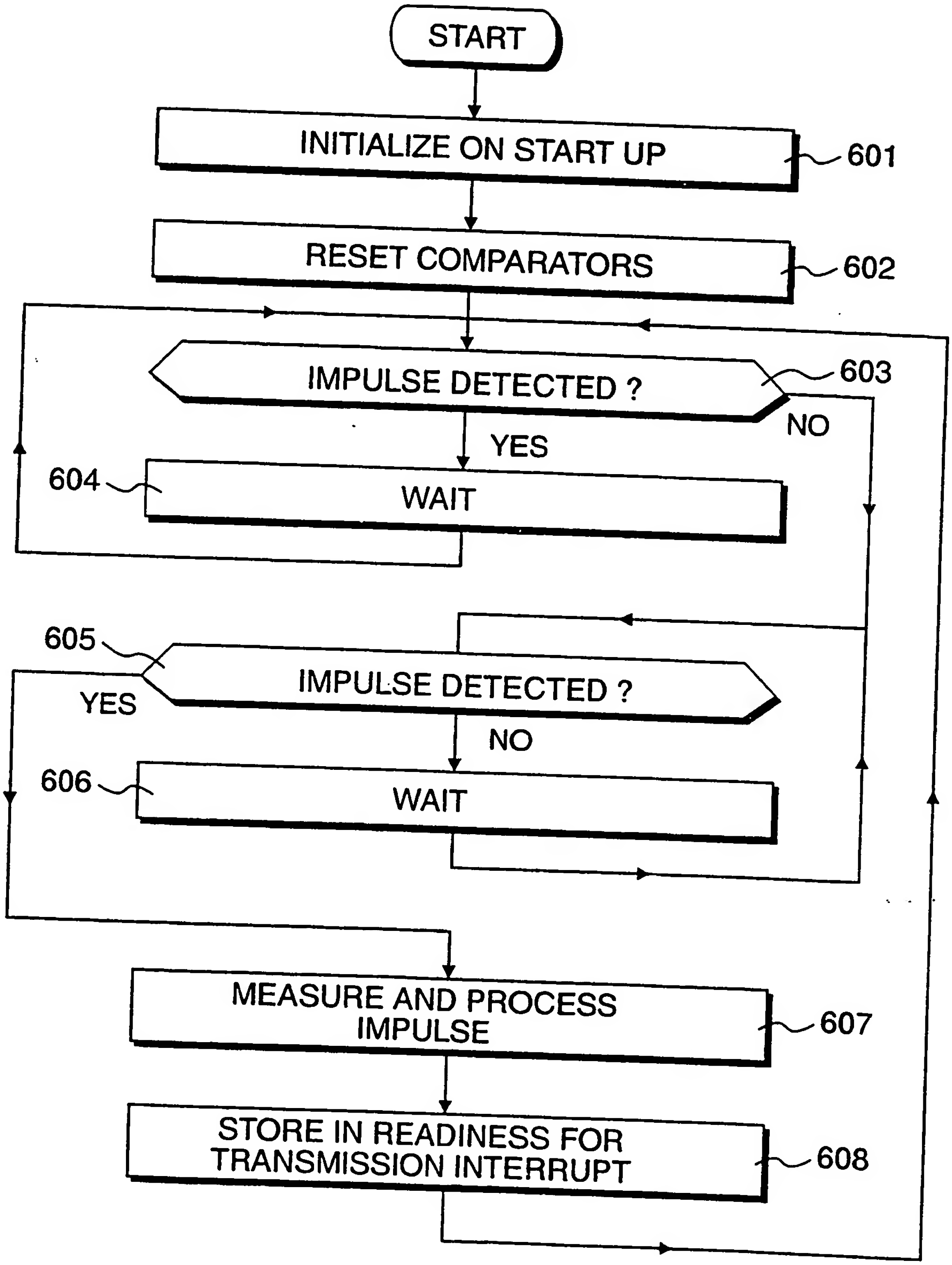
START
INITIALIZE ON START UP
601
RESET COMPARATORS
602
IMPULSE DETECTED ?
603
NO
YES
604
WAIT
605
IMPULSE DETECTED ?
YES
NO
606
WAIT
MEASURE AND PROCESS IMPULSE
607
STORE IN READINESS FOR TRANSMISSION INTERRUPT
608

Figure 6

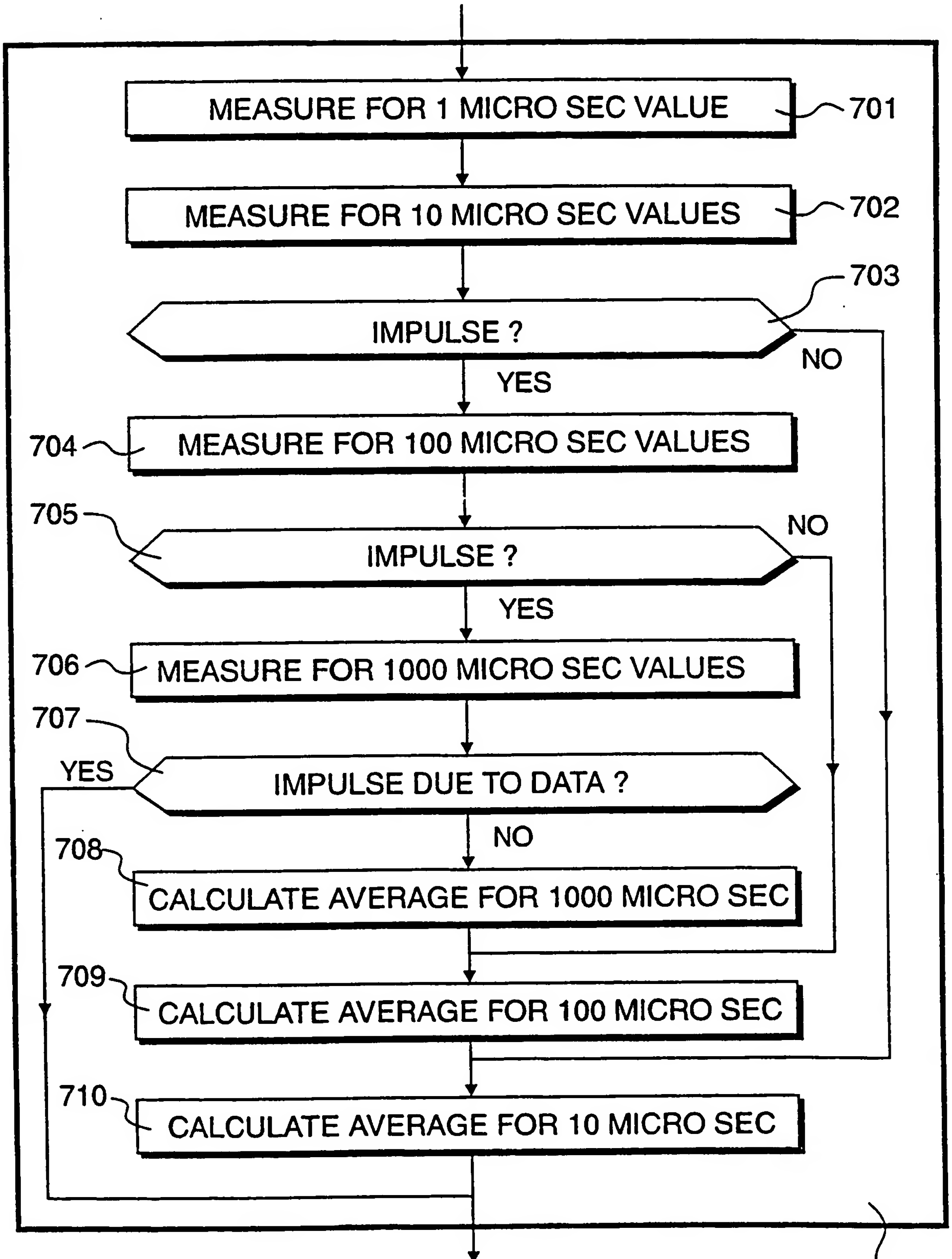
MEASURE FOR 1 MICRO SEC VALUE
701
MEASURE FOR 10 MICRO SEC VALUES
702
703
IMPULSE ?
NO
YES
704
MEASURE FOR 100 MICRO SEC VALUES
705
IMPULSE ?
NO
YES
706
MEASURE FOR 1000 MICRO SEC VALUES
707
YES
IMPULSE DUE TO DATA ?
NO
708
CALCULATE AVERAGE FOR 1000 MICRO SEC
709
CALCULATE AVERAGE FOR 100 MICRO SEC
710
CALCULATE AVERAGE FOR 10 MICRO SEC
607

Figure 7

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 98/01880

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04N17/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04N G01R H04B H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 221 967 A (WARD R. ET AL) 22 June 1993 see column 3, line 3 - line 41 see column 5, line 1 - line 13 ---	1,11,15
A	EP 0 730 381 A (AT&T) 4 September 1996 see column 1, line 32 - line 55 see column 3, line 39 - column 8, line 45 ---	1,11,15
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search: 5 October 1998

Date of mailing of the international search report: 15/10/1998

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Authorized officer
Verschelden, J

INTERNATIONAL SEARCH REPORT

Inter   ›nal Application No
PCT/GB 98/01880

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
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